



OLYMPIC REGION DESIGN & CONSTRUCTION CONFERENCE 2007

Cost Estimating Fundamentals



WEDNESDAY FEBRUARY 07, 2007
SW Washington Pipe Trades Training Center Rm. 152
9:40 am to 10:50 am
11:00 am to 12:10 pm

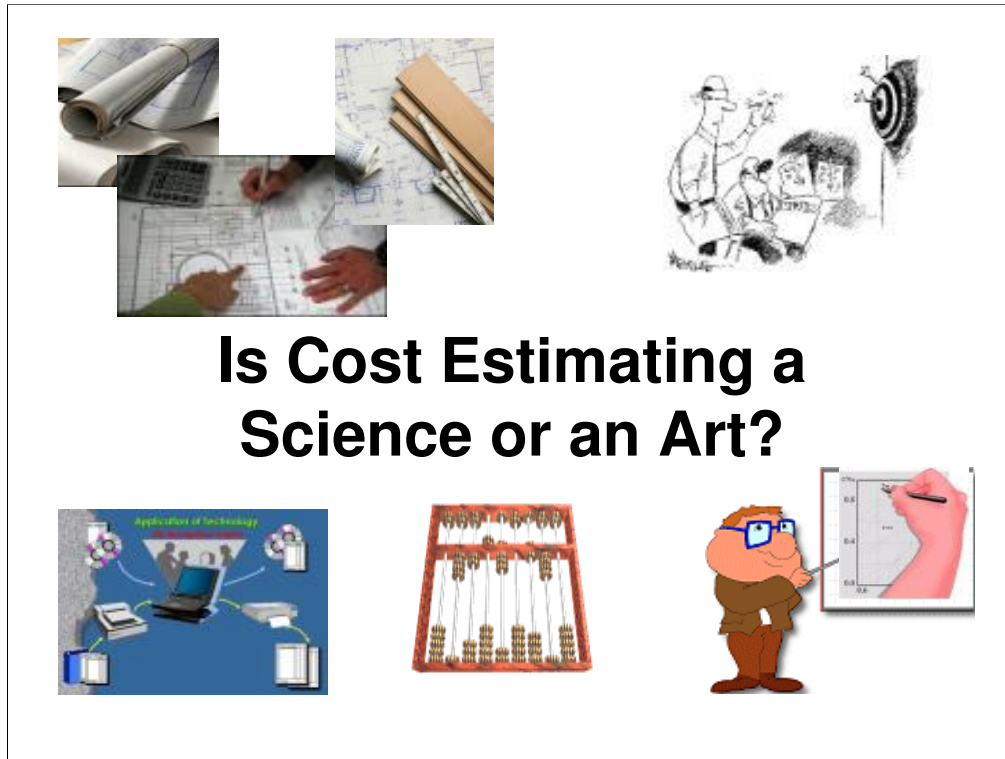




Cost Estimate: Why, When, Who, What, Where, and How



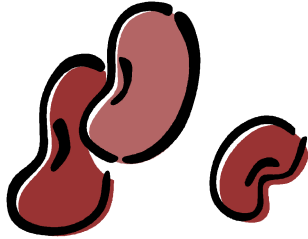
This session will focus on several issues related to cost estimating. For example, we will discuss **why** we do cost estimates and **why** they are important. We will discuss **when** we prepare estimates in terms of the WSDOT project development process. This discussion will also relate cost estimating to the WSDOT Project Management Process. We will also discuss **what** are the main issues and challenges related to preparing cost estimates. Because estimating is a multi-disciplinary effort, **who** prepares cost estimates is discussed. Cost estimates are prepared in many locations, thus, **where** they are performed is important. Finally, we will explore **how** estimates are prepared.



Let us discuss this question for a few minutes.

This is an interesting question. Most of you are planners or design personnel where your main project responsibilities are related to preparing technical information such as traffic operations analysis, concept drawings, preliminary plans and specifications. In the cost estimating field you use this information to prepare estimates. You have to interpret technical information and often make calculations to develop quantities of material for different items of work. This, perhaps, is the science involved in cost estimating. What then is the art in cost estimating? I would say the art is, for example, having the skill to conceptualize a work component, relate the construction of this component to the site conditions and then apply a unit price that reflects site conditions as well as current market conditions.

Cost Estimating Exercise



Scope: Fill Beans in Jar

**Requirement - Estimate
Weight of Beans Needed**



Prepare an estimate. Your scope of work is to fill this jar with pinto beans. You have some experience with pinto beans as you have a few of them.

Estimate the weight of the beans and the appropriate unit price; then the highest reasonable weight, THEN you will estimate the most likely weight of beans in the jar. You should record your estimate methodology.

Think of this as the 80% area under the bell curve, that is, the normal distribution (draw a picture of a bell curve on the board labeling the low, most likely, and high numbers, if necessary). Ask yourself, what is the probability of the actual weight of beans within your range? Record your answer. Use whatever tools you have to prepare your estimate.

Note: After this is completed ask each participant to provide their estimate starting with the most likely. Write this on the board and discuss the results. Repeat this with the ranges. Write down and discuss the results. Ask them how they developed their estimate, that is, what methodology did they use.

Reflect for a minute on how this exercise applies to cost estimating. Thoughts – use different methods based on level of information; the estimate ranges tighten when more information is available to estimate the number of beans; we tend to estimate on the low side; there is uncertainty in every estimate; the beans are the same but what if you had a mix of different beans how would this impact your estimate; and time to prepare an estimate impacts accuracy.

Goals

- Purpose – improve consistency and accuracy of cost estimates.
- Objective – increase knowledge and understanding of the cost estimating process and how this process is applied in the context of WSDOT project delivery and project management.

The purpose of the course really relates to improving consistency and accuracy of cost estimates regardless of when they are prepared in the planning and project development process.

We want you to better understand the cost estimate process and how this process is applied on WSDOT projects.

Suggested courses on estimating include: *Introduction to Project Development* (Course Code CF4), *Design Documentation* (Course Code BZ8) and *Project Management Process* (Course Code B71). This course will not cover cost estimating at the end of PS&E to prepare an Engineer's Estimate. This topic is covered under the *Contract Plans, Provisions, and Estimate Preparation* course (Course Code A4J). *Risk Based Transportation Cost Estimating* (Course Code CZ2)

Cost Estimating

Today you will learn:

- **Why, when, who, what, where, and how of estimating**
- **How cost estimating fits into Project Development and Project Management**
- **Factors that influence consistency and accuracy of cost estimates**
- **Methods, techniques, and tools used to prepare cost estimates**

There are five learning objectives for this session. The first three objectives focus on background information while the last two objectives really cover the “heart” of the session.

WHY

Cost Estimating

Why is Cost Estimating Important?

Used in making financial decisions!

- Basis for projecting funds for programs
- to prioritize projects in benefit/cost analysis
- Determining funds required to delivery projects
- Provides a baseline for Project Control
- To obligate specific funds for project phases
- Basis for cash flow requirements over time

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What types of financial decisions are made based on cost estimates?

WSDOT has a series of programs to address needs and deficiencies. These programs cost money. Cost estimates determine how much money is needed over some period of time to support key programs such as the Highway System Plan, Capital Improvement and Preservation Program, and the Biennial Program. Someone has to decide what projects have priority. WSDOT does not have sufficient funds to design and construction every project that is needed. Cost estimates can be used in benefit cost analyses to prioritize a list of projects within a program. Eventually, a cost estimate has to be prepared for a specific project. At some point in the project development time line this project cost estimate will become the baseline budget used to control the funds allocated to the project. Cost estimates are used to obligate funds such as for the biennial budget or for construction at bid. Finally, Program Management needs to know when the funds are needed so when an estimate is combined with a schedule a project cash flow or “aging curve” is prepared.

Finally the voters make financial decisions based on estimates.... Some projects are subject to advisory votes.

WHEN

Learning Objectives

- Identify how cost estimating fits into Project Development
- Understand Relationship between Cost Estimating and Planning and Project Development Process

WHEN Learning Objectives

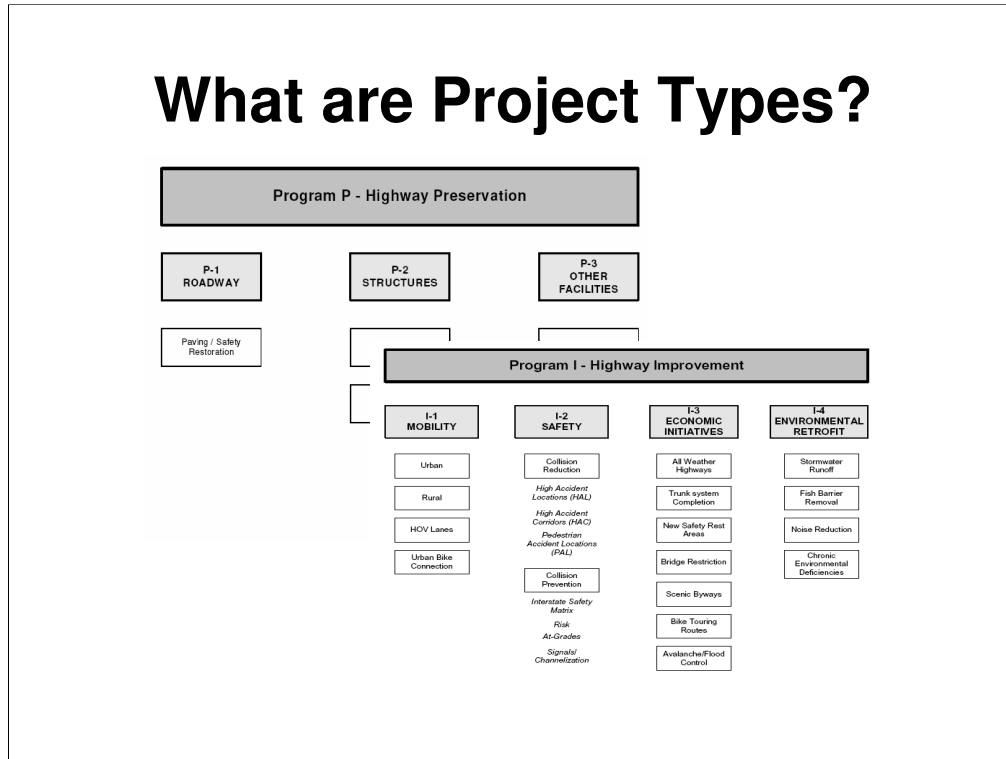
The specific learning objectives for this Module are:

- Review the planning and project development process from concept to completion of a project
- Understand how cost estimating fits into this process

Why do we want to do this? Some points are:

- Cost estimates serve different purposes at different points in project development
- While the cost estimating process follows the same steps, the inputs and outputs change over time
- Scope definition matures as the project is developed. This affects cost estimating techniques and tools that are used.

What are Project Types?



PROJECT TYPES - PRESERVATION

Projects in WSDOT programs are categorized as Preservation and Improvement. Preservation projects tend to be less complex and perhaps less difficult to estimate.

PROJECT TYPES - Improvement Projects

The type of projects under the improvement category tend to be more complex and perhaps more difficult to estimate.

The Cost Question?

- How much will the project cost?

The Follow-up Cost Question

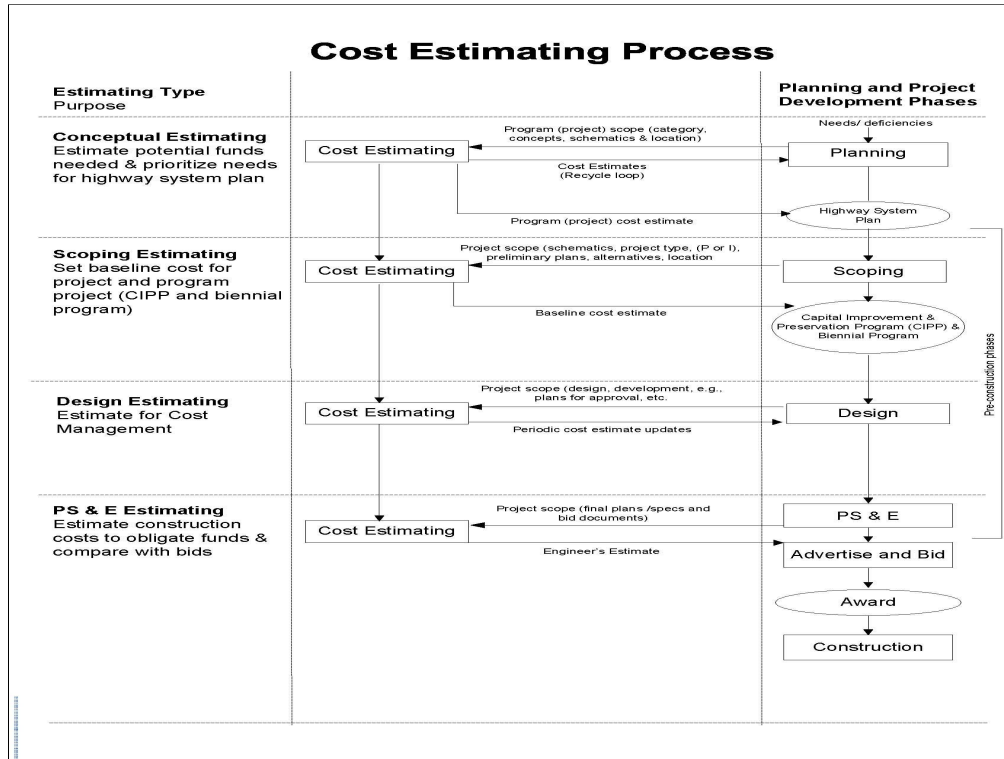
- Why does the project cost that much?

The Answer!

An estimate is not a single number

Key Cost Question

The answer to the cost question and cost follow up question is that estimates are prepared at different times during project development. Different stakeholders or entities may be asking these questions. For example, a legislator could ask these two questions for a project within their region and very early prior to when the project is programmed. Alternatively, the public may be asking either one of these questions but more likely the second question regarding why a project cost so much. Regional Management and HQ management are likely to ask these same questions to understand and be able to explain the costs for a project. A systematic estimating process employed at the right time during project development can help provide the answers. The answers are not single numbers but rather a range of numbers.



Interaction between Cost Estimating Process and the Project Development Process

Overall interaction between the planning and project development phases on the left hand side and cost estimating in the middle of the slide. The basic purpose behind the development of the cost estimate that supports each phase is shown on the left hand side of the slide.

More information about the planning and project development process can be found in the course *Introduction to Project Development* (Course Code CF4).

Cost Estimating and Planning (*Conceptual estimating*)

Where needs and deficiencies are converted into a set of projects that are ultimately be incorporated into the Highway System Plan. The Highway System Plan (HSP) is a plan that covers a 20 year period of potential projects. In order to prioritize and determine funds required to support the HSP, cost estimates are prepared. A basic input for these cost estimates is the scope definition or description of projects developed throughout the Planning phase. This scope definition is very limited at this point and may include concepts, schematic drawings, and boundary locations. Larger or mega projects may require more complete scope definition in order to estimate them.

Cost Estimating and Scoping (*Scoping Estimates*)

Where the basic scope is developed for a specific project that will be incorporated into the Capital Improvement and Preservation Program (CIPP) and/or the Biennial Program. The CIPP is a program that covers a six to ten year period of projects. The Biennial Program is the two year program that forms **The Book** of projects that is approved by the Legislature. In order to prioritize and determine funds required for these two programs, cost estimates are prepared. Key input for these cost estimates is the project scope, which is described in terms of preliminary plans, different alternatives, site characteristics, and other related project information. This information is developed through the Scoping process. The output of Scoping is a Project Summary. This summary has three parts – Project Definition, Design Decisions Summary, and Environmental Classification Summary. Backup support for the Project Summary can be very limited at this point for less complex projects such as pavers or much more detailed for complex mobility projects. At the end of the Scoping phase the design for a project could be anywhere between five and 25 percent complete.

Cost Estimating and Design (*Design Estimates*)

Where a specific project is designed with the intent of preparing final plans and specifications to support PS&E. The project scope, budget, and schedule for design and construction letting is included in the Capital Improvement and Preservation Program and/or the Biennial Program. As the design is prepared there is a need to develop periodic estimates. Key input for these cost estimates is plans for approval, and other relevant design documentation, that is developed throughout the Design phase. This scope definition is increasingly more defined as Design progresses. Changes in cost are documented on a Project Control Form.

Cost Estimating and PS&E (*Engineer's Estimate just prior to AD*)

Where final plans, specifications, and bid documents are prepared so a project can be Advertised and Bid for construction. Scope is completely defined at this point in project development as plans and specifications are 100 percent complete.

PS&E estimating process as is covered under the *Contract Plans, Provisions, and Estimate Preparation* course (Course Code A4J).

Project Development Phases and Cost Estimating Purpose

Development Phase	Purpose
Planning	Highway System Plan <ul style="list-style-type: none"> • Needs Prioritization using Benefit/Cost Analysis • Long Range Funding Levels
Scoping	Capital Improvement and Preservation Program and Biennial Program <ul style="list-style-type: none"> • Set Project Baseline Cost • Program Project
Design	Project Delivery <ul style="list-style-type: none"> • Cost Management
P S & E	P S & E <ul style="list-style-type: none"> • Obligate Funds • Compare to Contractor Bid

Purpose of Cost Estimating and Each Project Development Phase

This table summarizes the main purposes of cost estimates as prepared in each of the four major development phases.

Cost Estimating Significance

- Why is establishing an accurate cost estimate for setting a baseline budget important?
 - Legislature line item project specific budgets
 - Budgets difficult to change!
 - Costs cannot be managed without a baseline.

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Cost Estimating Significance

Another significant cost estimating issue is line item budgets approved by the Legislature. Line item budgets started with the Nickel gas tax. This budgeting approach continues with the 9.5 cent gas tax upheld in November 2005. It is likely to continue in the future. A line item budget substantially increases the importance of preparing accurate baseline cost estimates to support project budgets. This approach also places greater emphasis on project management and, in particular, Managing Scope, Schedule, and Budget and Managing Risks.

WHO

Who is Responsible for Cost Estimating?

- Planning Phase
 - Planners
- Scoping Phase
 - Project Development Engineers
 - Project Engineers/Design Leads
- Design Phase
 - Project Engineers
 - Design Leads

Estimate Responsibility

Responsibility for the Cost Estimating process changes as the project matures from planning to design. These changes are related to the planning and project development phase in which an estimate is being prepared.

Who Prepares Cost Estimates?

- Design Team
 - Planners
 - Project Engineers
 - Project Development Engineers
 - Design Leads
 - Engineers
- Specialty Groups
 - Traffic
 - Structures
 - Geotechnical and Materials
 - ROW/RES
 - Environmental and Hydraulics
 - Construction
 - Utilities

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Bottom Line – The Project Team!

Estimate Preparation

This Slide identifies some specific individuals who prepare cost estimates. Note that both design team members and different specialty groups prepare cost estimates. Thus, this effort is truly multi-disciplinary. However, the more personnel involved in cost estimating, perhaps, the more difficult the effort becomes with respect to coordinating the input of all individuals involved and ensuring that the project scope is accounted for in the based cost estimate.

Who are the Specialty Groups (Internal)? – WSDOT offices that specialize in disciplines that support project development. For example, Bridge, Communications, Environmental, Geotechnical, Hydraulics, Landscape, Materials, Program Management, Real Estate Services, Right of Way, Traffic, Utilities, and Work Zone Traffic Control are all internal specialty groups. More specific information about these groups and others can be found at:

URL -

http://www.wsdot.wa.gov/Projects/ProjectMgmt/OnLine_Guide/Phase_Guides/Pre-Construction/PC_Initiate_Align/PC_Team_Responsibilities.htm

Ultimately, responsibility for cost estimating requires a team effort!

WHAT

Cost Estimating

What is a Cost Estimate?

- a compilation of many elements
- approximates the probable quantity and unit cost of each of the elements
- is not a single number
- has uncertainty and risk associated with its elements and the project environment
- **is used as a basis for making financial decisions**

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Some key answers to the question, “What is a Cost Estimate?” include that an estimate is made up of many elements. However, the elements may not be completely defined at the time the estimate is prepared. A cost estimate is only an **approximation** of the **probable cost** of these elements. There is uncertainty associated with any estimate. There are unknowns that may not be understood. Remember then that an estimate is not a single number but more likely a range of numbers. Finally, a cost estimate is used to make financial decisions regarding a specific project or groups of projects also known as a program.

WHERE

Cost Estimating

Where is Cost Estimating Performed?

- At your desk and in the field.
- With your specialty groups.
- On the phone and on the computer.
- **Wherever you gather and document project items in terms of quantity and cost.**

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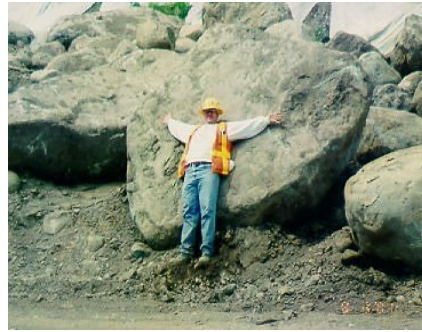
Where do you begin your project quantification? THROUGH RESEARCH and IN THE FIELD.

HOW

Unforeseen Conditions

Internal and External

- Unknown soil conditions
- Unknown utility locations
- Extent of ROW required
- Others???



What are Unforeseen Conditions?

Unforeseen conditions are notorious for causing project cost overruns. Unknown soil conditions can effect excavation, compaction, and structure foundations. Contaminated soils may be present resulting in the need for special mitigation work. Utilities are often present that are not described or described incorrectly on existing drawings. There are a multitude of problems that are simply unknown during the early project phases and which can increase project cost when they become apparent during construction (from NCHRP Project 8-49 Guidebook).

What are issues related to Unforeseen Conditions?

A sound approach to estimating unforeseen conditions is to thoroughly document estimate basis and assumptions especially in areas such as soil conditions, utility locations and right-of-way required. When the railroad is impacted by the project, assumptions related to the cost impact of working with the railroad companies should be clearly stated in the estimator's back up. Further, a risk analysis should attempt to quantify the impact if there is reason to believe that unforeseen conditions may be problematic in a certain area of the project.

Cost Estimating Techniques

- Parametric
- Historic Based
 - Bid pricing
 - Previous Project (Analogous Project per Project Management Institute)
 - Historical Percentages
- Cost Based
 - Forced Account
 - Bottoms Up
- CRA and CEVP Process
- Combinations

Parametric Estimating

Parametric estimating is primarily used to support development of planning level estimates where very little project scope definition is available. Major project parameters are identified. Statistical relationships and/or non-statistically based ratios between historical cost data and key project parameters are used to calculate the cost of various items of work (e.g., tons of asphalt, square foot of bridge deck).

Bid-Based Estimating

The use of historical data from recently bid contracts is the most common WSDOT estimating approach. Under this approach, bid data are summarized and adjusted for project conditions (i.e., project location, size, quantities, etc.) and the general market conditions. Line items are developed for major elements of work so that quantities and historical unit prices can be applied to these line items.

Previous Project (Analogous) Estimating

An estimating technique that uses the values of parameters, such as scope, cost, budget, and duration or measures of scale such as size, weight, and complexity from a previous, similar activity as the basis for estimating the parameter or measure for a future activity. It is frequently used to estimate a parameter when there is a limited amount of detailed information about the project (e.g., in the early phases). Analogous estimating is a form of expert judgment. Analogous estimating is most reliable when previous activities are similar in fact and not just in appearance, and the project team members preparing the estimates have the needed expertise.

Historical Percentages

This technique is used to estimate costs for items that are not defined. A percent is developed based on historical cost information from past projects to cover certain items. This percentage is based on a relationship between the items and a total cost category such as direct construction. Mobilization, Construction Engineering, and Preliminary engineering is often estimated based on a percent of construction.

Cost Based Estimating

This technique relies on a bottoms up approach to estimating wherein construction costs are estimated for labor and equipment based on estimated production rates, materials, contractor overhead, and contractor profit for each major line item. This means that labor and construction equipment resources are specifically identified for each element and tied to time–production–when these resources will be engaged on a construction operation. Estimates of preliminary engineering and construction engineering can be estimated from the bottom up based on for example, full time equivalent personnel and the time these personnel will be involved in the design or construction.

Cost Estimating Tools

- Cost per Mile
- Standard Item Table
- Spreadsheets
- EBASE
- Databases – Unit Bid Analysis, bidTabs Pro, Bid Ad and Award Data, RS Means
- Independent Investigation
- Cost Indices
- Risk Analysis with probabilities and simulation
- Internal and External Reviews
- Project Cost Estimate File

Tools

Techniques and Tools Matrix

Technique Tool	Parametric	Historical Based			Cost Based	CRA/CEVP
		Bid Pricing	Previous Project	Historical Percentages		
Cost Per Mile	√					
Standard Item Table		√	√	√		
Spreadsheets		√	√	√	√	
Ebase		√				
Unit Bid Analysis		√				
BidTabs Pro		√	√	√		
Ad and Award Date		√				
RS Means					√	
Independent Investigation		√			√	
Cost Indices						√
Risk Analysis	√	√	√	√	√	√
Internal/External						
Received						
Project Cost Estimate	√	√	√	√	√	√
File						

documentation

RESOURCES

There are many resources for cost estimating, including the following websites:

CREM OFFICE WEBSITE (CRA & CEVP)

<http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/>

(the cost estimate process can be found at this location)

NUMEROUS RESOURCES AT:

<http://www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/workshop.htm>

Such as: Project Estimate Basis Form, CRA/CEVP Workshop Request Form, Guidelines and other info.

PROJECT MANAGEMENT WEBSITE:

http://www.wsdot.wa.gov/Projects/ProjectMgmt/OnLine_Guide/Phase_Guides/Pre-Construction/Pre-Construction_files/slide0001.htm

STATE CONSTRUCTION OFFICE:

<http://wwwi.wsdot.wa.gov/eesc/cons/>

FERRY SYSTEMS COST ESTIMATING INFO:

<http://wwwi.wsdot.wa.gov/ferries/TerminalEngineering/CostEstimating.htm>